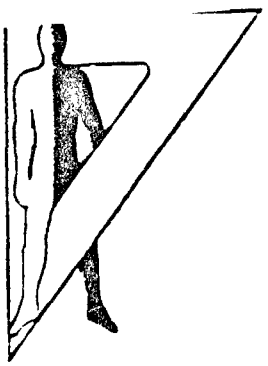

Technical Note 5-91

Stress Evaluation for the TOW Accuracy Study

Gerald A. Hudgens
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James C. Geddie
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November 1991
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Aberdeen Proving Ground, Maryland

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A TOW Accuracy Study was conducted in 1989 comparing TOW gunners' hit probabilities during mock battle conditions at the National Training Center (NTC), Fort Irwin, California, and during modified range conditions at Fort Hood, Texas. Since some observers have speculated that greater stress at NTC could adversely affect hit probabilities, an evaluation of stress experienced during the conditions created at the two sites was conducted. Psychological data obtained at the two sites were compared with each other and with similiarly obtained referent data for protocols involving surgical stress, examination stress, competition stress, and control conditions. It was concluded that the two sites were about equally stressful and, based on comparison with the referent findings, that the stress experienced was of a moderate level. Because the test plan did not control for test site order, the possible effects on performance that were because of test site factors could not be assessed. Implications of confounding order with test site were discussed and recommendations were offered for appropriate experimental designs for determining the possible effects of stress on hit probabilities.

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Subjective Stress Scale
State-Trait Anxiety Scale

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EXECUTIVE SUMMARY

In conjunction with the Test and Experimentation Command (TEXCOM) Combined Arms Test Center TOW Missile Accuracy Test, the U.S. Army Human Engineering Laboratory (HEL) conducted an evaluation of stress experienced by tube-launched, optically tracked, wire-guided (TOW) antitank missile system gunners. These gunners fired live missiles at Fort Hood, Texas, in July 1989 and at the National Training Center (NTC), Fort Irwin, California, in September 1989. The primary purpose of the TOW Missile Accuracy Test was to determine possible contributors to the historically poor performance with TOW at NTC relative to range conditions (TEXCOM Combined Arms Test Center, February 1990). One possibility is that NTC conditions are more stressful than range conditions; therefore, poorer performance could be a function of the greater stress experienced at NTC. The specific objective of the effort described in this report was to determine whether the gunners' perceptions of stress differed for the conditions of firing TOW at the two sites. This determination would either eliminate the likelihood or reinforce the possibility that the stress associated with firing during the two conditions differs in a manner that could affect firing performance.

The stress assessment was conducted by using psychological state questionnaires which have been shown in previous work to yield results similar to those for hormone measures across a variety of stressful situations. Activity monitors were also employed to assess the extent of possible differences in sleep deprivation stress experienced by the gunners at the two sites.

Results indicated that the TOW gunners were moderately stressed at both sites, but they were no more stressed by the firing during training conditions at NTC than by the firing during range conditions at Fort Hood. Therefore, it is concluded that for the conditions of this investigation, the differences in performance at the two sites are not attributable to a stress factor.

The data for sleep or rest patterns did not provide any indication that sleep deprivation should be greater at either site or that this variable might contribute to a stress or performance difference between sites.

Because the HEL stress assessment technique involves comparison of within-study data with independent reference group data, this investigation was able to provide a reasonable assessment of stress experienced by subjects while firing TOW missiles during range and NTC conditions. The TOW Accuracy Test Plan, which was established before any stress contributions at test sites were assessed, required testing subjects during modified range conditions before training and firing at NTC. Therefore, it was not determined whether the lower TOW hit probabilities, usually obtained at NTC compared to range conditions, were because of greater stress usually experienced at NTC. It seems likely that the usual NTC conditions for TOW firing would be more stressful than either condition in this study. In most cases, the usual NTC conditions combine the NTC operational factors with the anxiety associated with a first opportunity to fire live TOW missiles. Design considerations for pursuing this possibility were discussed.

STRESS EVALUATION FOR THE TOW ACCURACY STUDY

INTRODUCTION

In April 1988, the U.S. Army Materiel Systems Analysis Activity (AMSAA) was directed by the Assistant Secretary of the Army for Research, Development, and Acquisition to conduct a study of tube-launched, optically tracked, wire-guided [TOW] antitank missile system's accuracy that would provide improved data about hit probabilities for firing TOW missiles. AMSAA identified five phases in the study. The final two phases involved live firing of TOW missiles during modified range conditions at Fort Hood, Texas, in July 1989, and during the less structured, tactical training conditions of the National Training Center (NTC) at Fort Irwin, California, in September 1989.

An AMSAA representative contacted the U.S. Army Human Engineering Laboratory (HEL) and requested that HEL participate in the study by providing an assessment of human factors that could affect firing performance during the test conditions. After consideration of the conditions provided and constraints imposed in the proposed test plan (Test and Experimentation Command [TEXCOM] Combined Arms Test Center, June 1989), it was concluded that HEL could provide an assessment of the relative degree of stress imposed on the subjects during the various test conditions.

This report describes the results of the subsequent evaluation of the stress experienced by TOW gunners who fired live missiles at Fort Hood in July 1989 and at NTC in September 1989. The primary purpose of the TOW Missile Accuracy Test was to determine possible contributors to the historically poor performance with TOW at NTC relative to range conditions (TEXCOM Combined Arms Test Center, February 1990). One possibility is that NTC conditions are more stressful than range conditions; therefore, poorer performance could be a function of the greater stress experienced at NTC. The specific objective of the effort described in this report was to determine whether the gunners' perceptions of stress differed for the conditions of firing TOW at the two sites. This determination should either eliminate the likelihood or reinforce the possibility that the stress associated with firing during the two conditions differs in a manner which could affect firing performance. The specific primary hypothesis tested was that the Fort Hood and NTC firing conditions did not differ in the stress perceived by the gunners.

The stress assessment was limited (due to funding constraints) to the use of psychological state questionnaires that have been shown in previous work to yield results similar to those for hormone measures across a variety of stressful situations. In this regard, several of the instruments in the battery appear to be at least as useful as hormonal indicators of stress (Fatkin, Hudgens, Torre, King, & Chatterton, 1991; Hudgens, Fatkin, Torre, King, Slager, & Chatterton, 1991). Activity monitors were also employed to assess the extent of possible differences in sleep deprivation stress experienced by the gunners at the two sites. Activity patterns obtained with these monitors have shown a high correlation with sleep or rest patterns (Redmond & Hegge, 1985).

METHOD

Subjects

The primary subjects were 24 male soldiers, trained as TOW gunners (military occupational specialties [MOSs] 11H and 11M), from Fort Hood, Texas, and Fort Ord, California. This sample included eight gunners trained for each of the three TOW systems (IFV-Basic TOW, ITV-TOW II, and HMMWV-TOW II) used in

this study. Because of the limited number of vehicles that could be instrumented for the NTC phase, only four gunners using each system (a total of 12 gunners) were followed through both phases. None of the military TOW gunners were considered "experienced" since only three had previously fired a live TOW round.

In addition to the military gunners, two of the Army's most experienced civilian TOW test gunners (each having fired more than 100 live TOW rounds) were invited to participate in the Fort Hood phase. Their data are not included in the evaluation since they did not fire at both sites. Those data are, however, included in Appendix A.

Apparatus

According to the TEXCOM test plan, three TOW systems were employed: the IFV-Basic TOW, the ITV-TOW II, and the HMMWV-TOW II systems.

Walter Reed Army Institute of Research (WRAIR)/Precision Control Design wrist activity monitoring systems (Redmond & Hegge, 1985), provided by WRAIR, were used to monitor activity in sequential 2-minute time periods. The devices are small, unobtrusive, and have been successfully used in numerous field exercises without complication (e.g., Krueger, Redmond, Belenky, & Angus, 1987). They are low power (similar to a quartz watch), battery operated, self-contained and sealed, and involve no electrical contact with the subject. They normally cause no interference with the subject's personal or duty activity since they are worn like a slightly bulky wristwatch. Mole skin, wrist bands, or other padding is used to eliminate skin irritation that might occur with extended wear. There is no health risk in wearing these devices. The system is described in detail in Appendix B. The activity monitors were used to determine the sleep or rest patterns of the subjects during the time before each of the test conditions. Use of the monitors represents a way to assess one possible source of stress, fatigue, that could differ between sites. The levels of sleep or rest obtained at the two sites are reported in the same fashion described previously for overall stress.

The stress evaluation employed questionnaires that had been used in HEL-sponsored or in-house protocols, including the HEL Salvo Stress Study and Northwestern University stress protocols under contract (Fatkin et al., 1991; Hudgens et al., 1991). Three types of questionnaires were employed:

Survey questionnaires (approximately 30 minutes)

1. General Information and Health History Questionnaire.
2. Life Events (Form I, Recent) that asks subjects to rate the amount and type of stress they have "recently" experienced.

Trait questionnaires (approximately 40 minutes)

1. The State-Trait Anxiety Inventory (STAI) Form Y-2 (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) consists of 20 statements that assess how the respondents "generally" feel. The essential qualities evaluated by the STAI are feelings of apprehension, tension, nervousness, and worry.

2. The Multiple Affect Adjective Check List-Revised (MAACL-R), General form (Zuckerman & Lubin, 1985). This General or Trait form consists of five primary subscales (Anxiety, Depression, Hostility, Positive Affect, and Sensation Seeking) derived from a one-page list of 132 adjectives. An overall distress score, Dysphoria or Negative Affect, is calculated by adding the Anxiety, Depression, and Hostility subscale scores. The respondents are instructed to check all the words that describe how they "generally" feel.

3. The Sensation Seeking Scale (SSS), Form V (Zuckerman, 1979) contains four subscales (Thrill and Adventure Seeking, Experience Seeking, Disinhibition, and Boredom Susceptibility). Respondents are presented with a 40-item, forced choice questionnaire that is titled, "Interest and Preference Survey." A "Total" score is based on the sum of the four subscale scores.

4. Rotter's Internal-External Scale (Rotter, 1966) is used as a measure of locus of control. Respondents are asked to complete 29 forced-choice items (including six "filler" statements) relating to their locus of control beliefs. If individuals perceive that an event is the result of luck, chance, fate, or is controlled by powerful others, it contributes a belief in "external" control. If they perceive that the event is contingent upon their own behavior or their own relatively permanent characteristics, it is considered a belief in "internal" control.

5. The Eysenck Personality Questionnaire (EPQ) Short Form recognizes three distinct dimensions of personality: Extraversion-Introversion (E), Neuroticism (N), and Psychoticism (P) (Eysenck & Eysenck, 1975). The EPQ-E scale reflects the degree of a person's outgoing and assertive tendencies. When the EPQ-P and EPQ-N scales are used for the measurement of personality traits in normal persons, Eysenck and Eysenck (1975) describe them as measures of "emotionality," "tough-mindedness," or "stability-instability."

State (stress perception) questionnaires (approximately 10 minutes). A battery of stress perception measures that include

1. Form Y-1 (State Form) of the STAI (Spielberger et al., 1983). This is identical to the Trait form, except that subjects are instructed to answer according to how they feel "right now."

2. The Today Form of the MAACL-R (Zuckerman & Lubin, 1985). Because of the improved discriminant validity and the control of the checking response set, the MAACL-R has been particularly suitable for investigations that postulate changes in specific affects in response to stressful situations. This is identical to the Trait form, except that subjects are instructed to answer according to how they feel "right now."

3. The Subjective Stress Scale (SUBJ STRESS) was developed by Kerle and Bialek (1958) to detect significant affective changes in stressful conditions. Subjects are instructed to select one word from a list of 15 adjectives that best describes how they feel "right now."

4. The Specific Rating of Events scale (SRE) is a measure designed for the HEL stress program, wherein the subjects rate (on a scale of 0 for "not at all stressful" to 100 for "most stress possible") how stressful an event or time period was to them.

5. The Comparative Rating of Events scale (CRE), like the SRE, is also a measure designed for the HEL stress program, wherein the subjects rate (on the same scale of 0 to 100) how stressful an event or time period was to them, as compared with the most stressful event previously experienced during their lifetimes.

6. The Coping Efficacy scale asks respondents to rate (from 1 for "not at all confident" to 10 for "extremely confident") their level of confidence in their ability to do well. This scale is adapted from a self-efficacy scale developed by Bandura (1977) for investigating the predictive power of efficacy expectations as they relate to behavior or performance. Bandura (personal communication, December 31, 1985) suggested that self-efficacy scales be tailored to the testing situations through simple modifications in the instructions.

7. The Life Events Form-II is administered on the same day as the state measures and asks subjects to rate the amount and type of stress they have experienced within "the last 24 hours."

Procedure and Methodology

The HEL stress evaluation was conducted in conjunction with the final two phases of the TEXCOM TOW Missile Accuracy Test. The first phase was conducted at Fort Hood, Texas, during July 1989; the second phase was conducted at NTC at Fort Irwin, California, during September 1989.

Fort Hood Phase

Five to six days before test firing, the subjects were assembled in a classroom to be briefed about the study (including the HEL portion), to put on the activity monitors, and to complete surveys and trait and state (baseline) questionnaires. On TOW test firing days, each gunner participated in one "battle run" during which he fired four TOW missiles on stationary targets. The missile range had some conditions simulating the NTC environment (smoke, noise, mission-oriented protective posture [MOPP] gear, etc.). About 15 minutes before he was scheduled to leave a designated assembly area on the test site, each gunner was administered the battery of state questionnaires. Immediately after his battle run, when he returned to the assembly area (about 15 minutes after firing), he was again administered the battery of state questionnaires. The activity monitors were collected from the gunner when he had completed the post firing state questionnaires.

NTC Phase

This phase was conducted during a 2-week period in September 1989. Activity monitors were put on during the week before this period. On Thursday of the first week of NTC training, the soldier gunners participated in night and day live fire unit exercises firing on moving targets in a simulated battle. The "night" exercise was conducted between approximately 0500 and 0900, and the day exercise was conducted between approximately 1200 and 1400 the same day. The gunners were located in designated assembly areas before, between, and after the exercises. During the second week, they took part in a 24-hour unit force-on-force simulated battle using laser-equipped weapons. During the first week, state questionnaires were administered to the gunners in the designated assembly area shortly before the gunners left for the night exercise and immediately after they returned from the night and day exercises. Activity monitors were collected immediately following the second exercise. No data were obtained during the second week of training at NTC that consisted of force-on-force exercise using organic weapon systems equipped with the multiple integrated laser equipment system (MILES).

Experimental Design

The surveys and trait measures were used to determine the subjects' personality characteristics and to eliminate any persons with extreme personality traits or persons who might be experiencing a high level of stress unrelated to the study. The battery of state measures and the activity monitor provided dependent variable data. For the state measures and for the soldier gunners, the design can be considered a complete within-subject design with data obtained on a baseline day, and before and after the exercises at each site. The data obtained for the two civilian gunners during the Fort Hood phase serve only as an "ideal" reference, since they were extremely well practiced on the task. Their data were not included in the between-site stress evaluation, since they fired only during the Fort Hood phase.

Subject Scenario

Early during the week before the Fort Hood TOW accuracy range testing, the gunners arrived at Fort Hood. On Wednesday of that week, the gunners were assembled in a classroom setting to be briefed about the HEL portion of the study, to put on an activity monitor, and to complete the approximately 1-hour-plus battery, including the survey, state (baseline), and trait questionnaires. The next week, Monday and Tuesday, the gunners were tested in the TOW accuracy range test. Each gunner went through one "battle run" on one of those days and fired four TOW rounds during that time. The battle run involved the TOW crew moving its designated vehicle from the assembly area to the range firing point, the gunner firing four TOW missiles, and the crew moving its vehicle back to the assembly area. The distance from the assembly area to the range was about 0.25 mile. Each run took about 0.5 hour except when equipment malfunctioned or targets could not be located in time to fire a round before the target was withdrawn. In these cases, the runs were extended until all four rounds allotted were fired. Extended runs were completed within 1 hour. The following conditions, which are not usually applied to range tests, were incorporated into the Fort Hood range tests to eliminate distinguishing conditions between the sites: Pop-up targets that limited target exposure times were used instead of stationary targets, target ranges were varied, smoke and artillery simulators were used, and subjects were dressed in complete chemical protective clothing (MOPP IV). All runs were completed during daylight hours. Each gunner completed the state questionnaire battery about 15 minutes before leaving and about 15 minutes after returning to the assembly area from the battle run. The gunner turned in his activity monitor following completion of the post firing state battery. A subsample of 12 gunners was followed through the NTC phase 2 months later. About 1 week before leaving their home bases, the gunners were asked to put on reactivated activity monitors. During the first week at the NTC, the gunners participated in a 24-hour live fire battle exercise (including day and night operations) against moving targets. The time from departing from and returning to the assembly area was about 2 hours for both the day and night battles. About 15 minutes before departing the assembly area for the night battle and about 15 minutes after returning to the assembly area after the night and day battles, the gunners were again asked to complete the state questionnaire battery. The gunners turned in their activity monitors following completion of these questionnaires. Since one gunner's weapon malfunctioned, data are reported for only the remaining 11 gunners who fired during this phase.

RESULTS

The survey and trait questionnaires were used to provide information that could exclude as subjects those whose recent experiences indicated that they were under very high stress because of factors unrelated to the current assessment or those whose personality characteristics were so extreme that they might be classified as displaying clinical abnormalities. No subjects were excluded by these criteria. Relevant data from these measures are summarized in Appendix C.

Psychological State Measures

Fort Hood Data

The mean scores (and standard errors of the means, [SEMs]) obtained for the psychological state measures for the military subjects tested at Fort Hood are shown in Table 1. Three subjects were released early from the holding area, where they were to be given the psychological measures, and were sent to the firing line before pre firing data could be obtained. Although the post firing data were complete for the 24 military subjects tested during this phase, means and SEMs are shown for the 21 subjects whose data were complete for analysis over both phases.

Table 1

Mean Scores (±Standard Error) for Psychological State Measures Obtained From 24 Military Subjects at Fort Hood

	Measurement Times		
Measure	Orientation N=24	Pre Firing N=21	Post Firing N=21
MAACL-R			
Anxiety	58.9 (4.7)	64.2 (4.5)	65.9 (4.3)
Depression	66.1 (8.7)	53.5 (4.8)	57.7 (6.1)
Hostility	67.2 (6.6)	59.1 (6.3)	66.1 (6.7)
Positive Affect	49.8 (2.2)	53.1 (2.4)	51.7 (2.2)
Sensation Seeking	53.1 (1.5)	57.1 (2.2)	64.9 (2.0)
Dysphoria	67.9 (7.6)	62.0 (5.5)	68.1 (5.5)
STAI Anxiety	52.6 (1.3)	50.6 (0.7)	48.6 (1.1)
SUBJ STRESS	28.5 (4.1)	40.0 (4.9)	38.0 (5.7)
SRE	39.8 (6.8)	42.1 (5.6)	56.7 (6.4)

Psychological state data were first collected at an orientation several days before firing, a time that was expected to be relatively nonstressful, for comparison with data obtained near the time of firing. It is obvious when the orientation data from Table 1 are compared with those data for the Independent Control and Stress groups presented in Figures 1 through 9, that the orientation data were not characteristic of nonstress control conditions. For most of the measures, the orientation scores appear more like those for the stress conditions than for the nonstressed control condition. A plausible explanation for this is that most subjects were kept in a hot room with nothing to do for over an hour awaiting the late arrival of the remaining subjects before completing the psychological measures. Since these data clearly do not represent those expected for control conditions, they could not be used for a within-subject determination of stress-related reactions to the effects of firing TOW missiles.

Pre and post firing data for the nine psychological state measures shown in Table 1 were analyzed by multivariate analysis of variance (MANOVA) for the 21 military subjects with complete data for this phase. The Measures x Timepoints interaction effect was not significant indicating no significant state changes because of firing at Fort Hood (Univariate $F = 1.74$; $df = 8, 160$; $p < 0.10$; Wilks' $\lambda = 0.38$; Multivariate $F = 2.61$; $df = 8, 13$; $p = .06$).

NTC Data

The mean scores (and SEMs) obtained for the pre and post firing psychological state measures for subjects who fired TOW at both Fort Hood and NTC are shown in Table 2. Of the 12 TOW gunners studied at Fort Hood, who were scheduled to be monitored at NTC as well, one was removed from the sample because of system failure at the NTC test site. Additionally, there was a failure to obtain measures for 4 of 11 remaining subjects following the night battle as conditions interfered with coordination of study personnel with the subjects. A MANOVA for the data obtained for the seven subjects for nine measures following the night and day battles indicated the Measures x Trials interaction was not significant (Univariate $F = 0.45$; $df = 8, 48$; $p = .882$). Since the number of subjects was quite small for the night battle data, and the night and day results did not differ significantly, the analyses for the stress assessment are limited to the day battle data. The night battle data are summarized in Appendix D. Data were complete for 11 subjects on the pre firing and post firing (day battle) data. The MANOVA Measures x Timepoints interaction was not significant (Univariate $F = 0.382$; $df = 8, 80$; $p = .927$; Wilks' $\lambda = 0.119$; Multivariate $F = 2.784$; $df = 8, 3$; $p = .216$).

Fort Hood (Range)/NTC Comparisons

The relative stress experienced at the two test sites can be evaluated by comparing the psychological state data obtained at the two sites at both the pre firing and post firing time points. Nine subjects provided complete data over those four time points. The Measure x Time Point x Test Site interaction was not significant ($F = 0.004$; $df = 1, 9$; $p = .953$), but the Measure x Test Site interaction was significant ($F = 5.961$; $df = 1, 8$; $p = .040$). Post hoc contrasts (Tukey-Kramer modification of the Tukey HSD test [Wilkinson, 1988]) for each measure indicated that the mean MAACL-R Anxiety was greater at Fort Hood ($X = 65.1$) than at NTC ($X = 55.6$) ($F = 9.069$; $df = 1, 8$; $p = .017$). Two other measures showed similar trends but were not significant: MAACL-R Positive Affect, which was greater at Fort Hood ($X = 52.7$) than at NTC ($X = 46.8$) ($F = 3.488$; $df = 1, 8$; $p = .099$), and STAI Anxiety which was greater at Fort Hood ($X = 49.9$) than at NTC ($X = 47.4$) ($F = 4.029$; $df = 1, 8$; $p = .080$).

Table 2

Mean Scores (±Standard Error) for Psychological State Measures Obtained From 11 Military Subjects who Fired at Both Fort Hood and NTC

	Measurement Time					
	Fort Hood			NTC		
Measure	Orientation N=11	Prefiring N=9	Postfiring N=11	Prefiring N=11	Postfiring (Night) N=7	Postfiring (Day) N=11
MAACL-R						
Anxiety	68.0 (7.8)	68.3 (6.4)	60.0 (3.3)	51.0 (2.0)	51.0 (2.3)	59.7 (4.7)
Depression	77.1 (17.0)	52.6 (3.5)	65.3 (11.3)	73.1 (8.8)	57.3 (7.2)	70.7 (8.0)
Hostility	82.9 (11.9)	62.3 (11.1)	80.1 (12.4)	79.5 (10.7)	78.1 (15.9)	84.7 (11.1)
Positive Affect	45.0 (3.2)	56.4 (4.1)	49.6 (2.9)	45.9 (2.3)	45.6 (4.9)	47.1 (2.0)
Sensation Seeking	50.6 (1.8)	54.8 (3.4)	64.7 (3.2)	55.5 (3.1)	58.4 (3.5)	60.7 (2.5)
Dysphoria	83.5 (13.6)	67.3 (7.1)	78.8 (8.2)	71.7 (6.4)	65.9 (9.4)	77.1 (9.7)
Anxiety (STAI)	51.7 (1.5)	51.2 (0.9)	48.8 (1.4)	48.4 (1.1)	48.0 (1.1)	47.7 (1.6)
SUBJ STRESS	35.8 (6.6)	41.2 (6.2)	42.3 (8.1)	33.0 (4.7)	43.9 (11.7)	37.9 (6.0)
SRE	46.3 (9.2)	39.3 (8.0)	51.5 (9.4)	30.3 (8.3)	38.1 (13.8)	44.5 (8.7)
CRE			50.1 (10.0)			38.6 (9.3)
Coping Efficacy	7.4 (0.5)	8.3 (0.4)		8.7 (0.4)		

The CRE, since it was obtained only once at each site, was analyzed by a t-test for paired samples for 10 subjects who provided these data and fired at both sites. Although they rated their experience as more stressful at Fort Hood ($\bar{X}$ = 49.1; SEM = 11.0) than at NTC ($\bar{X}$ = 36.6, SEM = 9.3) the difference was not statistically significant (t = 1.19; df = 9; p = .264). Coping Efficacy did not change significantly from pre firing at Fort Hood to pre firing at NTC ($\bar{X}_{diff}$ = 0.2, t = 0.48, df = 9, p = .642).

Comparisons With Other Protocols

A previous stress evaluation has demonstrated the utility of protocol comparisons for estimating the relative stress experienced in a given situation (Fatkin et al., 1991). The referent protocols for the present evaluation are as follow:

ABDMSURG - men visiting a hospital on a day when their wives were facing abdominal surgery under general anesthesia.

WREXAM - third-year male medical students taking a written examination required for completion of the clerkship portion of their medical training.

SSCOMP - male soldiers representing elite units in marksmanship competition.

SSCNTRL - male soldiers performing the same marksmanship task as SSCOMP, but no competition was promoted.

INDCNTRL - men investigated during normal work days when they were experiencing no unusual stress.

Figures 1 through 10 show the mean pre and post stress scores (± SEM) for the 10 measures used for the five referent protocols and for the TOW gunners who fired at Fort Hood and NTC.

MANOVAs were conducted to compare the Fort Hood data and NTC data with the data obtained in other protocols which used the same measures and procedures. Both pre and post data were available for all measures except SRE and CRE. Data for measures with both available were analyzed in Groups (6) x Pre/Post Timepoint (2) x Measures (9) designs. Since only post data were complete across protocols for SRE and CRE, those data were analyzed in Groups (6) x Measures (2) designs. Since the highest order interactions were highly significant in all cases (as shown in the following paragraphs), subsequent analyses for protocol differences were conducted for each pre and post measure separately:

Fort Hood: Groups (6) x Timepoint (2) x Measures (9) interaction effect (Univariate F = 5.15; df = 40, 1064; p = .000; Wilks' λ = 0.34; Multivariate F = 3.90; df = 40, 552; p = .000).

Fort Hood: Groups (6) x Measures (2) interaction effect (F = 4.35; df = 5, 144; p = .001).

NTC: Groups (6) x Timepoint (2) by Measures (9) interaction effect (Univariate F = 5.72; df = 40, 984; p = .000; Wilks' λ = 0.26; Multivariate F = 4.66; df = 40, 508; p = .000).

NTC: Groups (6) x Measures (2) interaction effect (F = 4.61; df = 5, 130; p = .001).

Data for the groups that fired at Fort Hood and NTC were compared in separate analyses with data for the five referent groups. Analyses were accomplished using Dunn's multiple comparison procedure (also known as Bonferroni t statistics [Kirk, 1968]) with $\alpha = .01$ for each of the five a priori comparisons with referent groups for an overall $\alpha = .05$.

MAACL-R Anxiety

Inspection of Figure 1 shows both pre and post anxiety levels for subjects firing TOW at Fort Hood were at levels comparable to those for the WREXAM and SSCOMP protocols. Pre anxiety was significantly higher at Fort Hood than for either the SSCNTRL or INDCNTRL protocols. Post anxiety was significantly higher than for the SSCNTRL protocol ($p = .01$) but not the INDCNTRL protocol ($p = .03$) and was significantly lower than that for the ABDMSURG protocol ($p = .01$).

Pre and post anxiety for the subjects firing at NTC were not significantly different from control protocol levels but were significantly less than for the ABDMSURG protocol ($p = .01$ for both pre and post anxiety).

MAACL-R Depression

Inspection of Figure 2 shows that both pre and post depression levels for subjects at Fort Hood were comparable to those for the two referent control protocols. Their depression differed (significantly lower) only from the ABDMSURG protocol during the post period ($p = .01$).

For the subjects at NTC, pre depression was significantly higher than that of any of the referent protocols ($p = .01$ to $.000$). As shown in Figure 2, this post depression level was nearly identical with pre depression, comparable with the ABDMSURG protocol, but differences between their post depression and the referent protocols did not attain statistical significance.

MAACL-R Hostility

Inspection of Figure 3 shows that hostility was generally elevated for subjects firing at both sites. For the subjects firing at Fort Hood, the pre hostility was significantly elevated relative to only the INDCNTRL protocol ($p = .01$). Their post hostility was significantly elevated relative to both the ABDMSURG and INDCNTRL protocols ($p = .002$ and $.005$, respectively).

For the subjects at NTC, pre anxiety was significantly elevated over all other protocols ($p = .000$ for all comparisons). Their post hostility was significantly elevated relative to all except the SSCOMP protocol (for comparisons with ABDMSURG, $p = .000$; WREXAM, $p = .001$; SSCNTRL, $p = .003$, and INDCNTRL, $p = .000$).

MAACL-R Positive Affect

For subjects at Fort Hood, post positive affect was significantly higher than the SSCOMP protocol ($p = .007$), but neither pre nor post positive affect differed from any other protocol.

Inspection of Figure 4 shows generally low levels of positive affect for subjects at NTC. Their pre positive affect was significantly lower than the SSCOMP and SSCNTRL protocols ($p = .01$) and the INDCNTRL protocol ($p = .000$). Their post positive affect, however, was significantly lower than only the INDCNTRL protocol ($p = .001$).

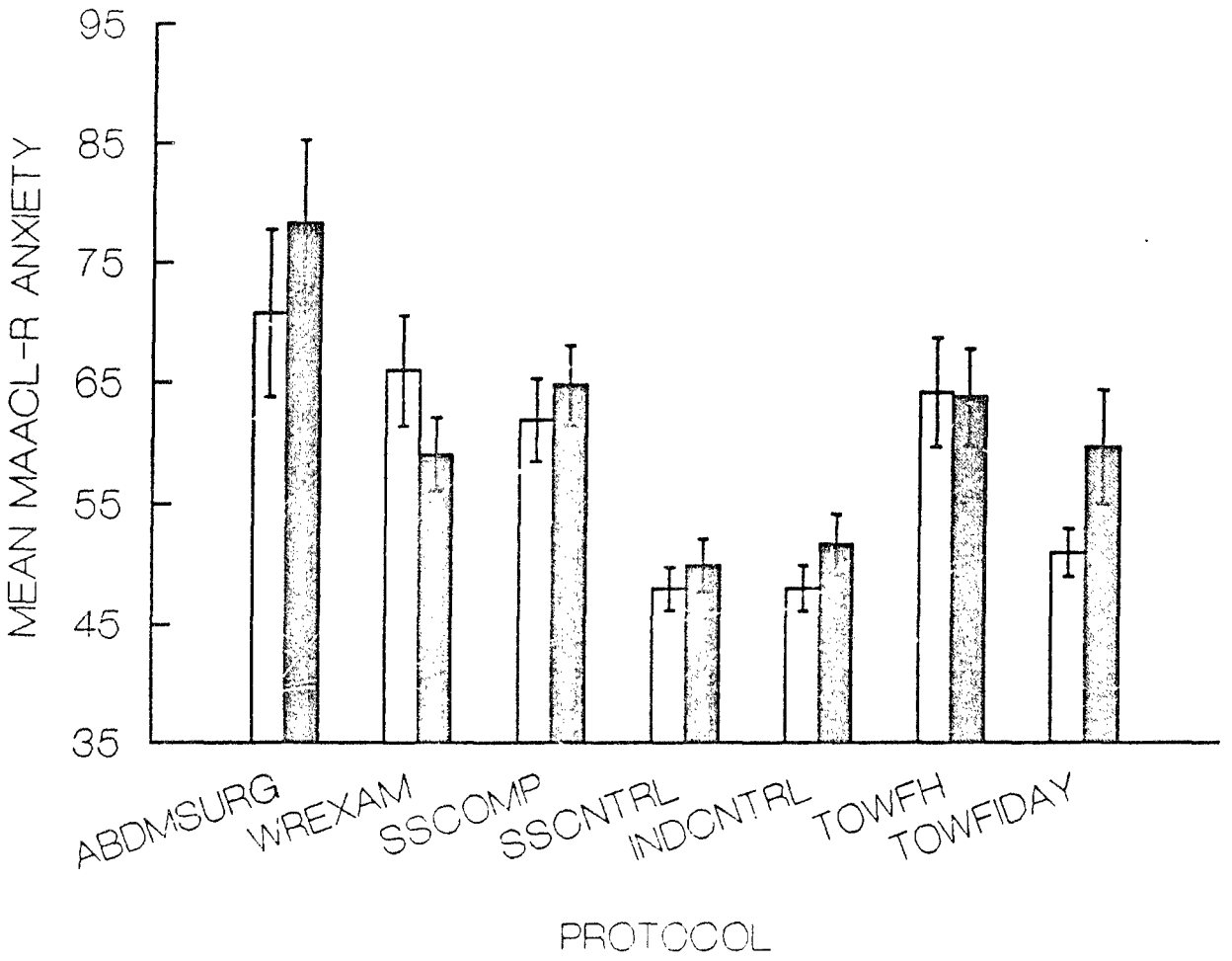

Figure 1. Comparison of mean (±standard error) pre and post event MAACL-R Anxiety scores for TOW gunners firing at Fort Hood (TOWFH; N=24) and at NTC (TOWFIDAY; N=11) with scores for men in the following referent protocols:

ABDMSURG; N=17: men whose spouses were undergoing serious abdominal surgery;

WREXAM; N=26: male medical students taking an important written medical exam;

INDCNTRL; N=23: men in an independent non-stressed control group;

SSCOMP; N=40: male soldiers in weapon-firing competition;

SSCNTRL; N=20: male soldiers in weapon firing without competition.

Open bars = pre event; shaded bars = post event.

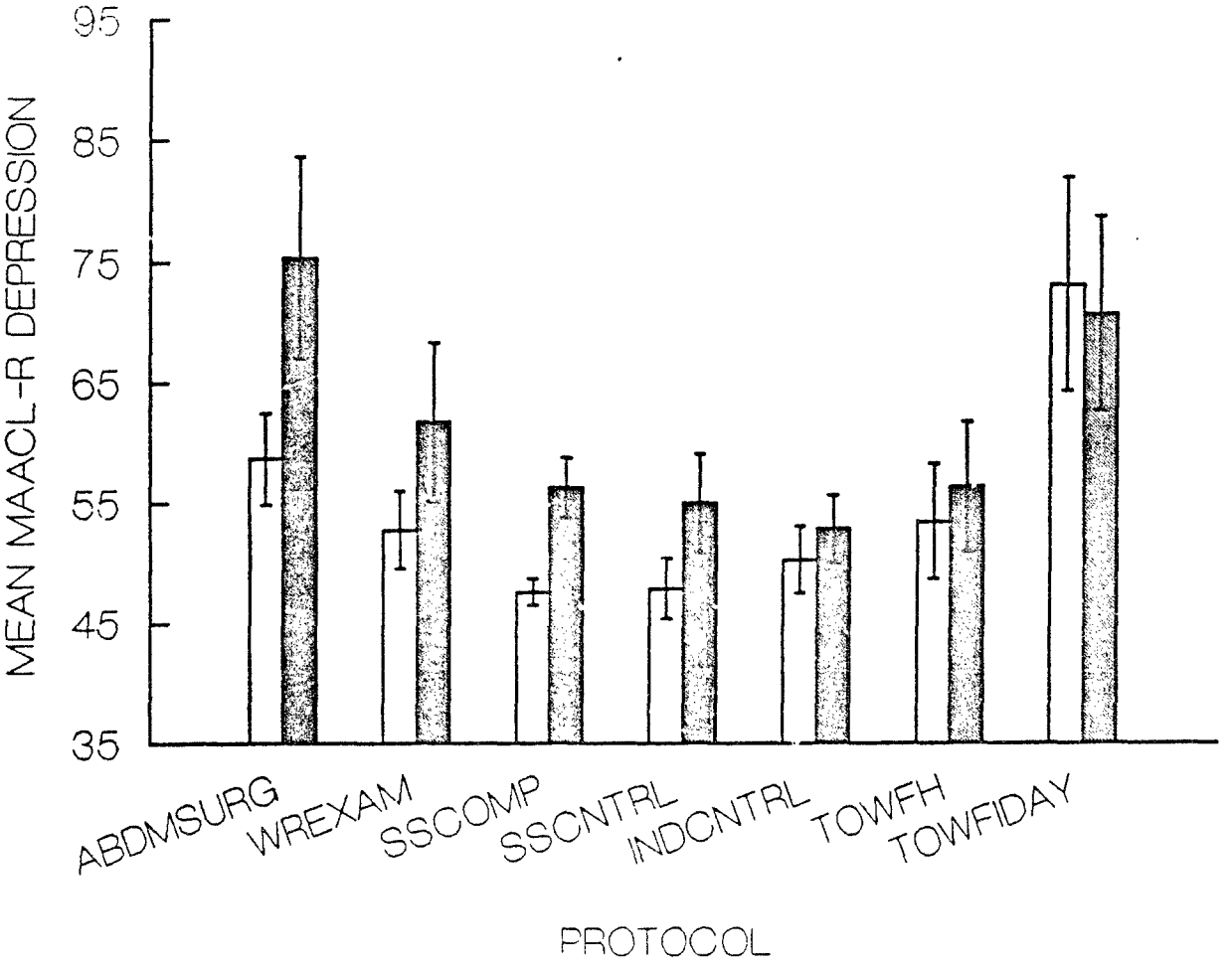

Figure 2. Comparison of mean (±standard error) pre and post event MAACL-R Depression scores for TOW gunners firing at Fort Hood (TOWFH; N=24) and at NTC (TOWFIDAY; N=11) with scores for men in the following referent protocols:

ABDMSURG; N=17: men whose spouses were undergoing serious abdominal surgery;

WREXAM; N=26: male medical students taking an important written medical exam;

INDCNTRL; N=23: men in an independent non-stressed control group;

SSCOMP; N=40: male soldiers in weapon-firing competition;

SSCNTRL; N=20: male soldiers in weapon firing without competition.

Open bars = pre event; shaded bars = post event.

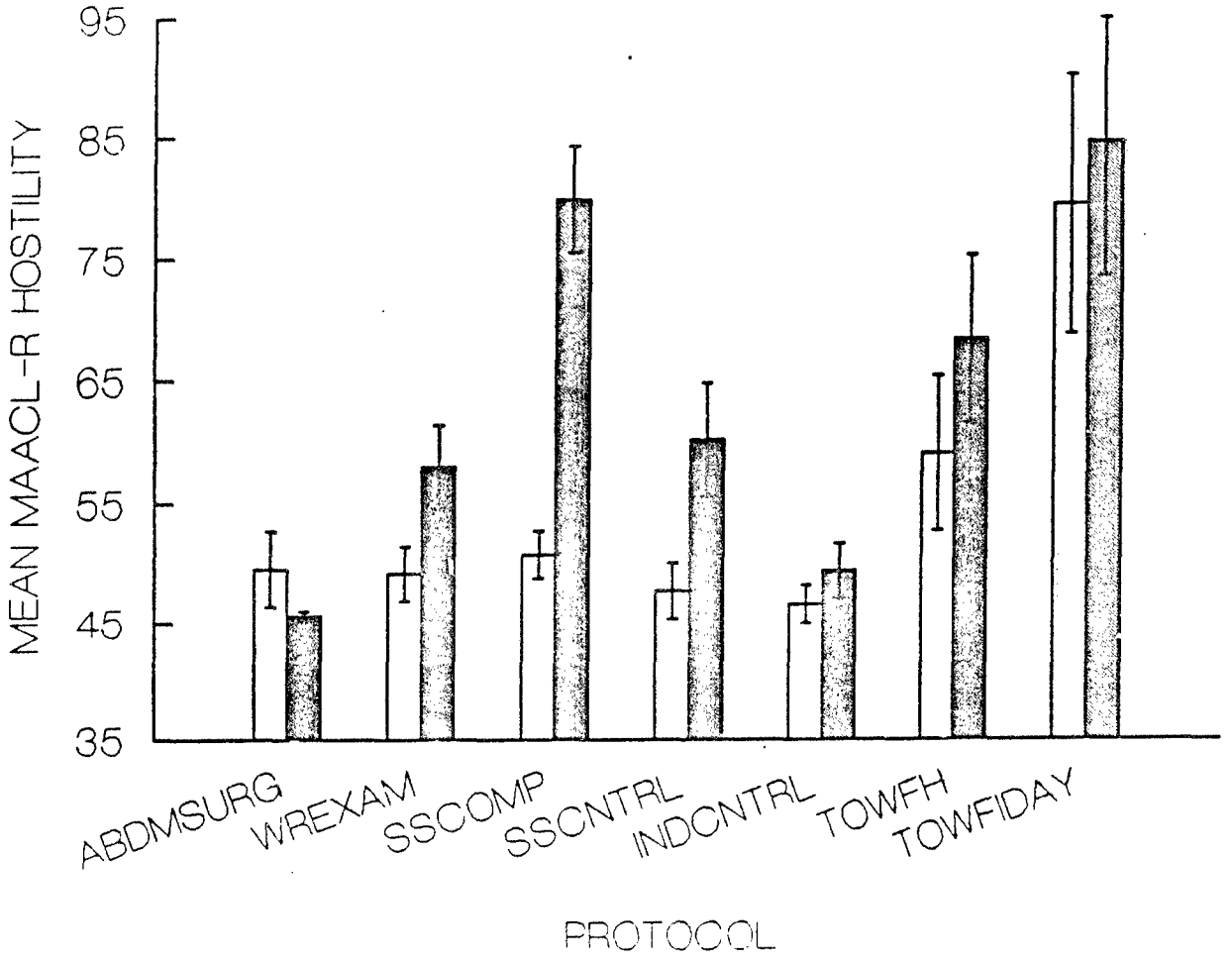

Figure 3. Comparison of mean (±standard error) pre and post event MAACL-R Hostility scores for TOW gunners firing at Fort Hood (TOWFH; N=24) and at NTC (TOWFIDAY; N=11) with scores for men in the following referent protocols:

ABDMSURG; N=17: men whose spouses were undergoing serious abdominal surgery;

WREXAM; N=26: male medical students taking an important written medical exam;

INDCNTRL; N=23: men in an independent non-stressed control group;

SSCOMP; N=40: male soldiers in weapon-firing competition;

SSCNTRL; N=20: male soldiers in weapon firing without competition.

Open bars = pre event; shaded bars = post event.

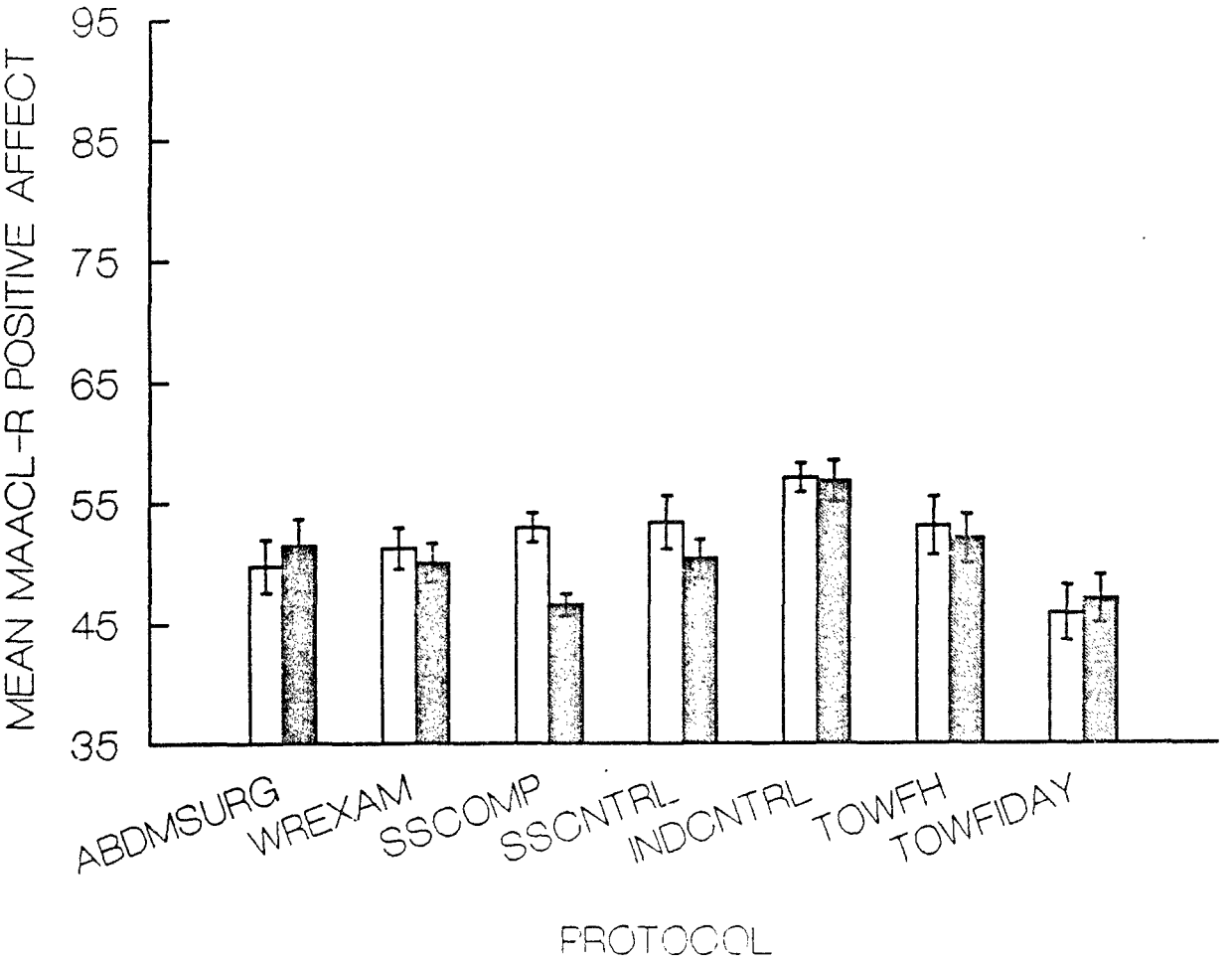

Figure 4. Comparison of mean (±standard error) pre and post event MAACL-R Positive Affect scores for TOW gunners firing at Fort Hood (TOWFH; N=24) and at NTC (TOWFIDAY; N=11) with scores for men in the following referent protocols:

ABDMSURG; N=17: men whose spouses were undergoing serious abdominal surgery;

WREXAM; N=26: male medical students taking an important written medical exam;

INDCNTRL; N=23: men in an independent non-stressed control group;

SSCOMP; N=40: male soldiers in weapon-firing competition;

SSCNTRL; N=20: male soldiers in weapon firing without competition.

Open bars = pre event; shaded bars = post event.

MAACL-R Sensation Seeking

Inspection of Figure 5 shows that the subjects at both sites tended to exhibit patterns of elevated sensation seeking similar to that for the SSCOMP and SSCNTRL protocols. For the subjects at Fort Hood, the sensation seeking was significantly elevated during the pre period over the ABDMSURG ($p = .000$) and INDCNTRL ($p = .004$) protocols and during the post period over the same two protocols and the WREXAM protocol ($p = .000$ for all three comparisons).

For the subjects at NTC, the elevation in sensation seeking was significant for the pre period only over the ABDMSURG protocol ($p = .009$). For the post period, sensation seeking was elevated significantly over the ABDMSURG ($p = .000$), WREXAM ($p = .001$), and INDCNTRL ($p = .000$) protocols.

MAACL-R Dysphoria

As shown in Figure 6, the subjects at both sites displayed elevated levels of dysphoria comparable to the highest for other stress protocols. The subjects at Fort Hood exhibited pre dysphoria that was significantly elevated over the SSCNTRL ($p = .008$) and INDCNTRL ($p = .006$) protocols. The elevation was significant for the post period only relative to the INDCNTRL protocol ($p = .01$).

For the subjects at NTC, pre dysphoria was significantly elevated over the SSCOMP ($p = .008$), SSCNTRL ($p = .000$) and INDCNTRL ($p = .000$) protocols, and post dysphoria was significantly elevated over the SSCNTRL ($p = .01$) and INDCNTRL ($p = .002$) protocols.

STAI Anxiety

Results for this measure were not as clear as for most of the other state measures, including the MAACL-R Anxiety subscale (see Figure 7). For the subjects at Fort Hood, STAI pre anxiety was significantly higher than only the SSCNTRL protocol ($p = .003$), and their post anxiety was significantly lower than the ABDMSURG protocol ($p = .000$). For the subjects at NTC, the only significant difference in anxiety relative to referent groups was for post anxiety, which was significantly lower than the ABDMSURG protocol ($p = .001$).

SUBJ STRESS

As for the previously described STAI anxiety measure, the subjective stress ratings did not distinguish well between the TOW protocols and the referent protocols (see Figure 8). The only difference that achieved statistical significance was pre subjective stress for the subjects at Fort Hood, which was significantly elevated relative only to the INDCNTRL protocol ($p = .01$).

SRE

Inspection of Figure 9 shows that subjects at both sites exhibited post stress ratings for this measure comparable to those for the other stress protocols. The ratings for subjects at Fort Hood were significantly elevated over those for the SSCNTRL ($p = .009$) and INDCNTRL ($p = .000$) protocols. For subjects at NTC, the elevation was significant only relative to the INDCNTRL protocol ($p = .003$).

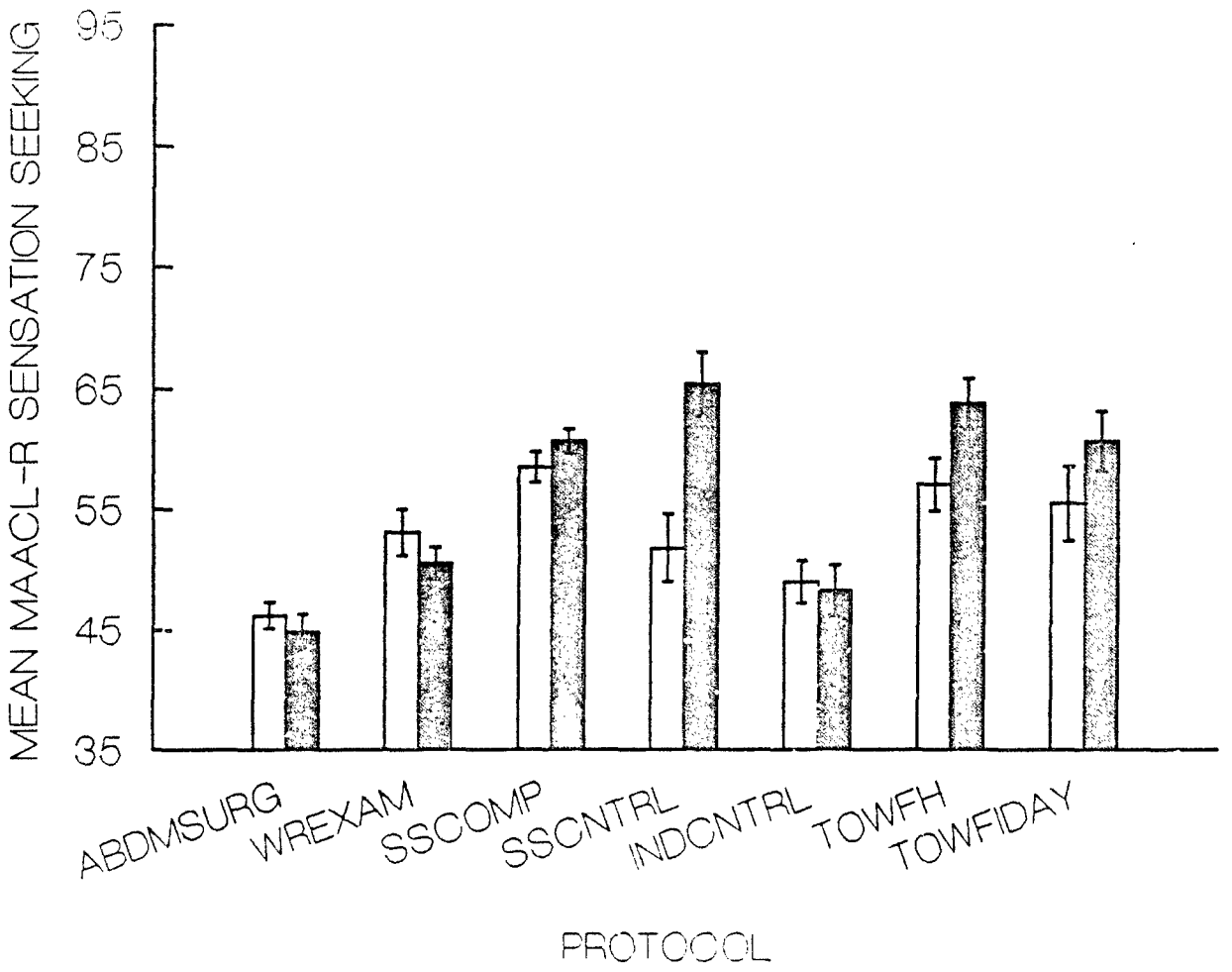

Figure 5. Comparison of mean (±standard error) pre and post event MAACL-R Sensation Seeking scores for TOW gunners firing at Fort Hood (TOWFH; N=24) and at NTC (TOWFIDAY; N=11) with scores for men in the following referent protocols:

ABDMSURG; N=17: men whose spouses were undergoing serious abdominal surgery;

WREXAM; N=26: male medical students taking an important written medical exam;

INDCNTRL; N=23: men in an independent non-stressed control group;

SSCOMP; N=40: male soldiers in weapon-firing competition;

SSCNTRL; N=20: male soldiers in weapon firing without competition.

Open bars = pre event; shaded bars = post event.

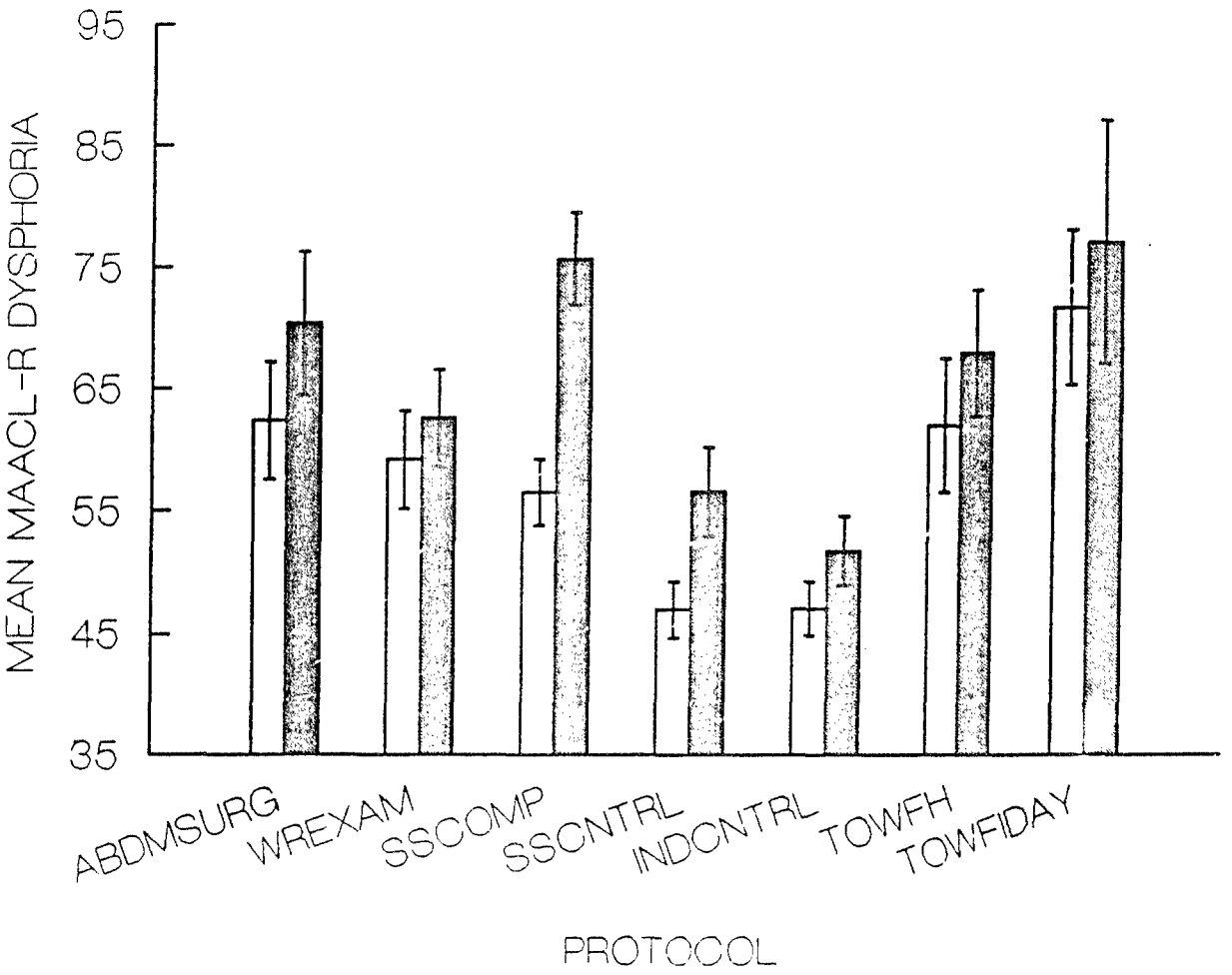

Figure 6. Comparison of mean (±standard error) pre and post event MAACL-R Dysphoria scores for TOW gunners firing at Fort Hood (TOWFH; N=24) and at NTC (TOWFIDAY; N=11) with scores for men in the following referent protocols:

ABDMSURG; N=17: men whose spouses were undergoing serious abdominal surgery;

WREXAM; N=26: male medical students taking an important written medical exam;

INDCNTRL; N=23: men in an independent non-stressed control group;

SSCOMP; N=40: male soldiers in weapon-firing competition;

SSCNTRL; N=20: male soldiers in weapon firing without competition.

Open bars = pre event; shaded bars = post event.

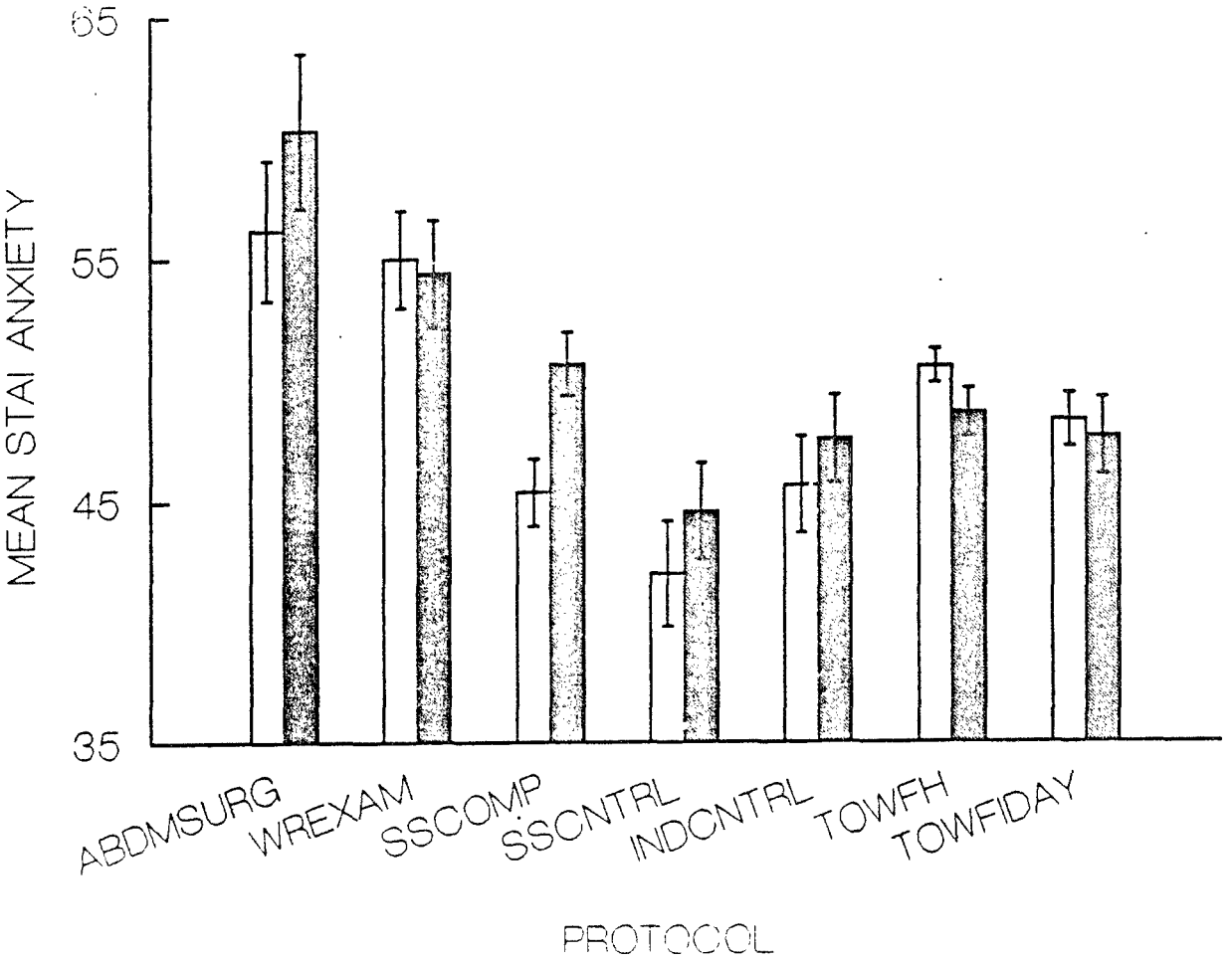

Figure 7. Comparison of mean (±standard error) pre and post event STAI Anxiety scores for TOW gunners firing at Fort Hood (TOWFH; N=24) and at NTC (TOWFIDAY; N=11) with scores for men in the following referent protocols:

ABDMSURG; N=17: men whose spouses were undergoing serious abdominal surgery;

WREXAM; N=26: male medical students taking an important written medical exam;

INDCNTRL; N=23: men in an independent non-stressed control group;

SSCOMP; N=40: male soldiers in weapon-firing competition;

SSCNTRL; N=20: male soldiers in weapon firing without competition.

Open bars = pre event; shaded bars = post event.

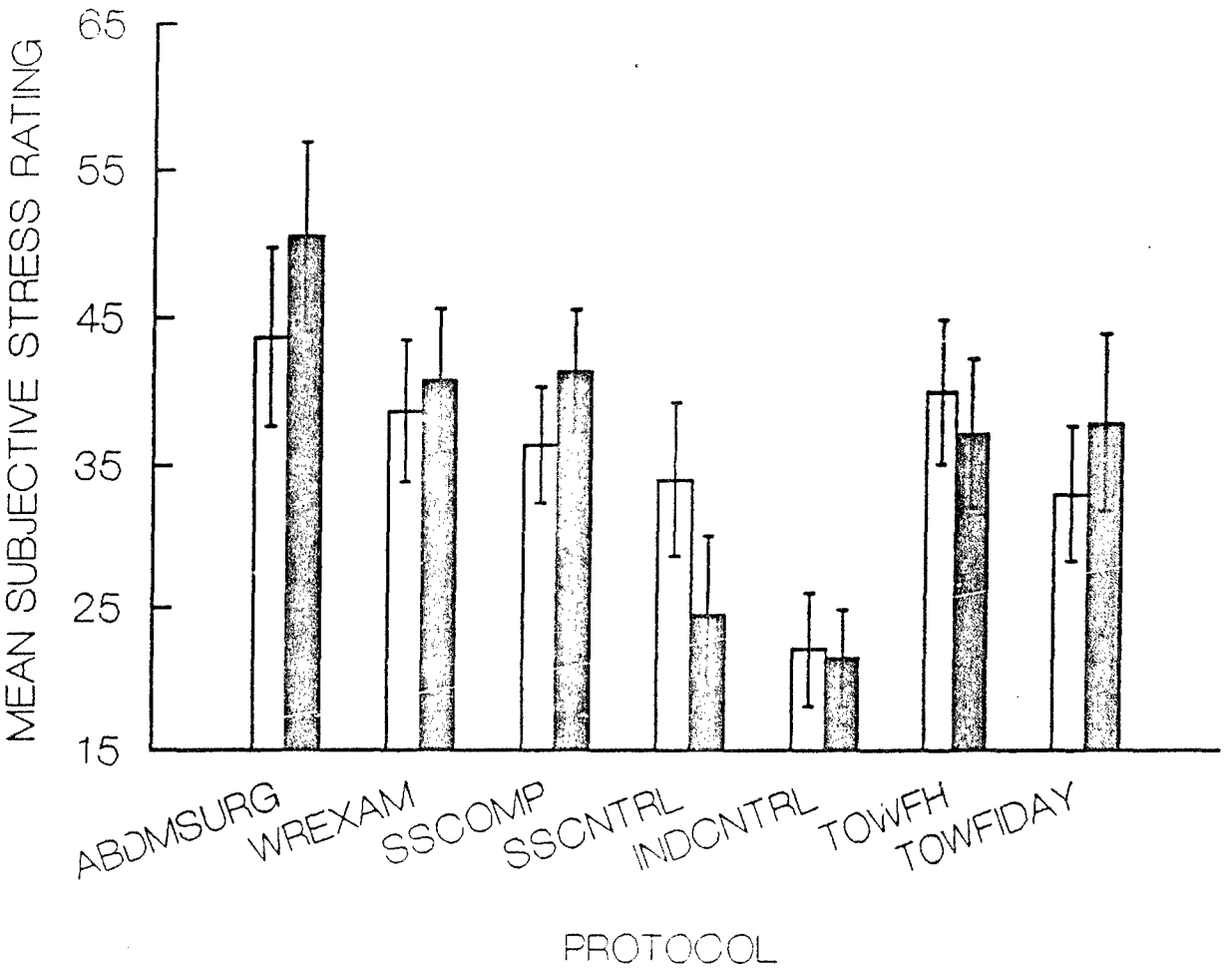

Figure 8. Comparison of mean (±standard error) pre and post event SUBJ STRESS scores for TOW gunners firing at Fort Hood (TOWFH; N=24) and at NTC (TOWFIDAY; N=11) with scores for men in the following referent protocols:

ABDMSURG; N=17: men whose spouses were undergoing serious abdominal surgery;

WREXAM; N=26: male medical students taking an important written medical exam;

INDCNTRL; N=23: men in an independent non-stressed control group;

SSCOMP; N=40: male soldiers in weapon-firing competition;

SSCNTRL; N=20: male soldiers in weapon firing without competition.

Open bars = pre event; shaded bars = post event.

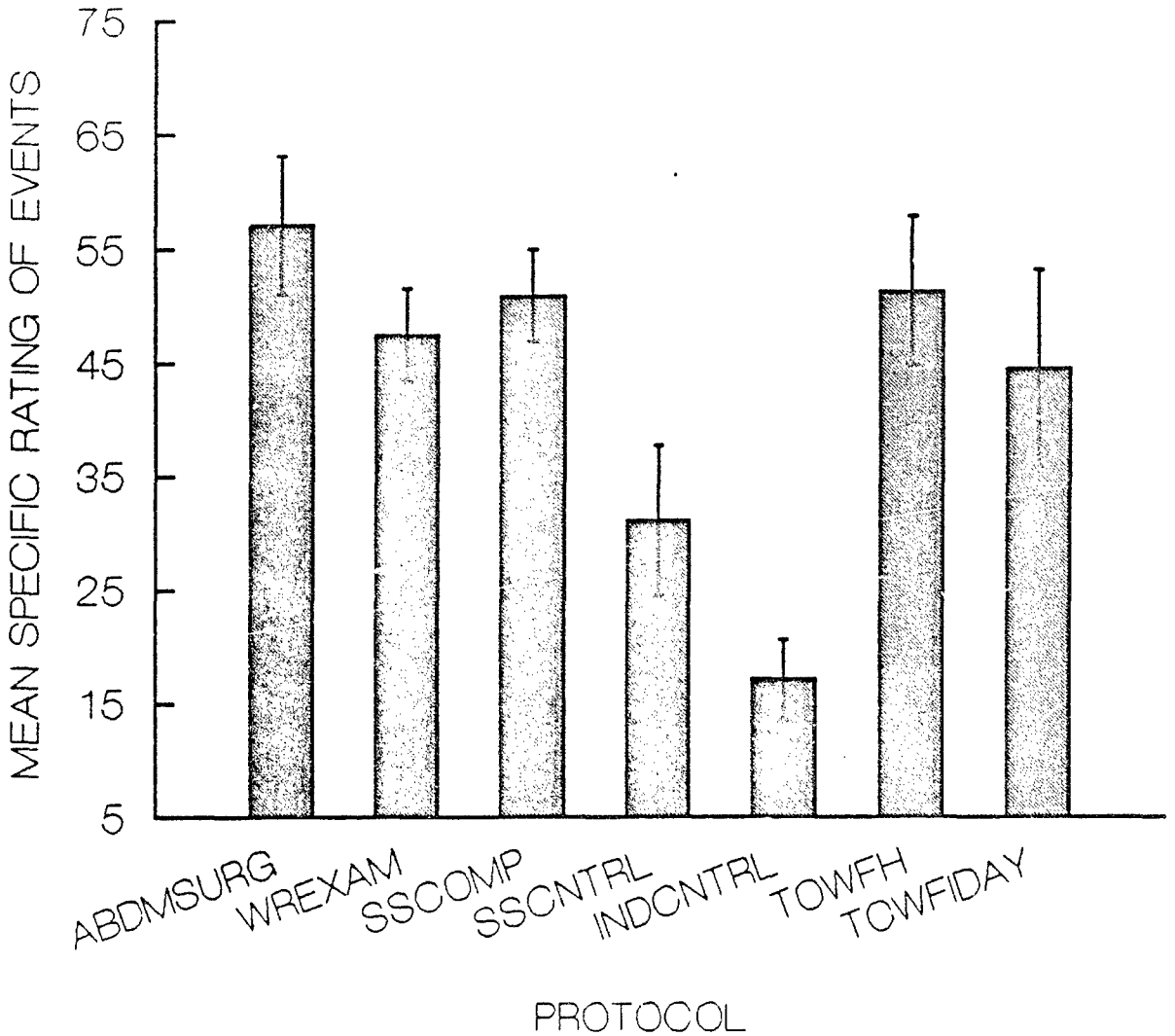

Figure 9. Comparison of mean (±standard error) post event SRE ratings for TOW gunners firing at Fort Hood (TOWFH; N=24) and at NTC (TOWFIDAY; N=11) with scores for men in the following referent protocols:

ABDMSURG; N=17: men whose spouses were undergoing serious abdominal surgery;

WREXAM; N=26: male medical students taking an important written medical exam;

INDCNTRL; N=23: men in an independent non-stressed control group;

SSCOMP; N=40: male soldiers in weapon-firing competition;

SSCNTRL; N=20: male soldiers in weapon firing without competition.

CRE

Compared with the most significant previous stress event in their lives, the subjects at Fort Hood reported stress ratings significantly higher than for the SSCNTRL ($p = .01$) and INDCNTRL ($p = .000$) protocols, but not significantly different from the referent stress protocols (see Figure 10). The subjects at NTC also reported stress ratings significantly higher than the SSCNTRL ($p = .004$) and INDCNTRL ($p = .001$) protocols, and significantly lower than the ABDMSURG protocol ($p = .007$).

Activity Measure

Activity patterns of the subjects were monitored to determine the amount of sleep or rest they experienced during the days before firing TOW at each site. The NTC training requirements at NTC were expected (based on anecdotal reports) to result in subjects having less opportunity for sleep or rest than at Fort Hood before their firing TOW.

In spite of strong appeals to subjects to continuously wear their monitors several days before firing TOW, compliance at Fort Hood was quite low. The low compliance, along with a number of apparent malfunctions of activity monitors, resulted in usable data for 7 of the 24 subjects during the last 3 days before firing and for only 4 of the 24 subjects on the fourth day before firing. The poor compliance was probably because subjects had several unsupervised days, including a full weekend preceding their firing TOW. At NTC, a lack of free time plus a strong reminder of the importance of continuously wearing the monitors, resulted in usable data for 12 to 13 subjects during the last 4 days before firing.

Inspection of the sleep or rest means and SEMs, presented in Table 3, indicates that these data do not reflect any meaningful differences in either the amount or patterns of sleep or rest obtained during the 4 days before firing at the two sites. Formal statistical analyses were not conducted because of the small number of subjects with usable data for the Fort Hood portion, and because the usable data obtained were not for the same subjects across time points. Furthermore, inspection of the data revealed that the apparent differences between sites were neither large nor consistent during 24-hour time blocks for any measure. Finally, it appears that the conditions at both sites allowed subjects to avoid sleep or rest deprivation; they averaged more than 8 hours of sleep or rest per 24 hours during Days 2 through 4 before firing and more than 6 hours of sleep or rest during the last day before firing.

Relationships Between Psychological and Sleep Measures and Performance

The performance by the TOW gunners in this study was in line with the historical data for gunners during range and NTC conditions as described in the TOW Accuracy Study Test Plan. That is, hit probabilities were substantially reduced during NTC conditions as compared with range conditions (TEXCOM Combined Arms Test Center, February 1990).

Unfortunately for the performance evaluation and for assessing relationships with performance at the two sites, the selection of a subsample of Fort Hood gunners to be followed at NTC was not unbiased regarding Fort Hood performance. That is, the average hit probability for Fort Hood range conditions was substantially higher in the subsample followed at NTC than for the whole group at Fort Hood. This selection of better performers from Fort Hood might be expected to have the effect of producing higher hit probabilities at NTC for the selected subgroup than might be expected had the entire group been followed through both conditions. Furthermore, the Fort

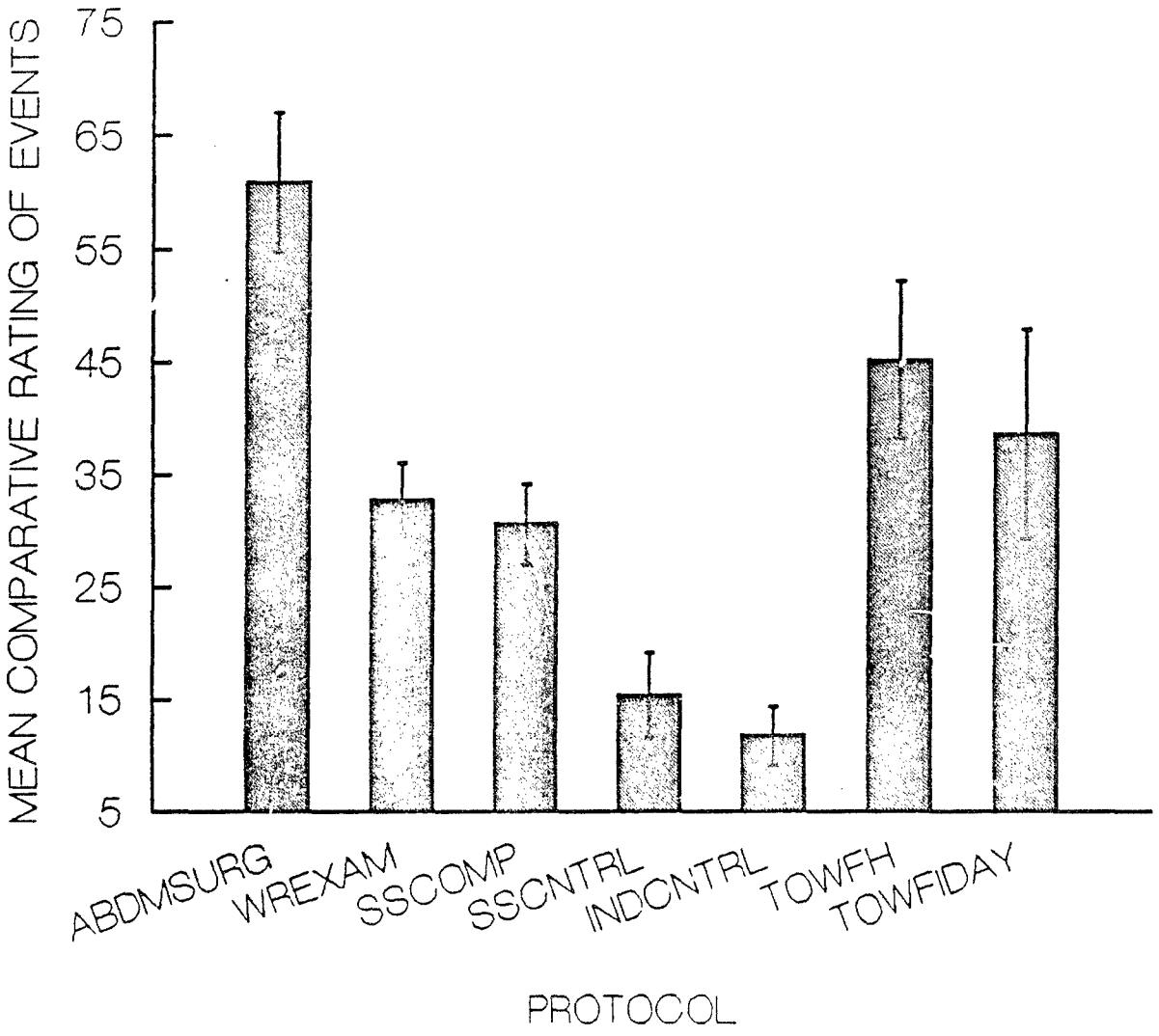

Figure 10. Comparison of mean (±standard error) post event CRE ratings for TOW gunners firing at Fort Hood (TOWFH; N=24) and at NTC (TOWFIDAY; N=11) with scores for men in the following referent protocols:

ABDMSURG; N=17: men whose spouses were undergoing serious abdominal surgery;

WREXAM; N=26: male medical students taking an important written medical exam;

INDCNTRL; N=23: men in an independent non-stressed control group;

SSCOMP; N=40: male soldiers in weapon-firing competition;

SSCNTRL; N=20: male soldiers in weapon firing without competition.

Hood hit probabilities for the subsamples of gunners for subsystems followed at NTC were not representative of the total sample for those subsystems at Fort Hood. Legitimate analysis of the performance data is therefore necessarily limited to data for subjects in the subsamples for site comparisons (as for the stress comparison in this document).

Table 3

Sleep or Rest Data for Days Before Firing at Fort Hood and NTC

Location	24-Hour Time Blocks Before Firing			
	0-24 hours	24-48 hours	48-72 hours	72-96 hours
Fort Hood				
No. of subjects	7	7	7	4
Mean No. sleep episodes (±SEM)	4.3 (.7)	3.7 (.8)	4.3 (.8)	4.5 (.3)
Mean hours sleep (±SEM)	6.6 (.6)	8.9 (1.1)	9.2 (1.1)	10.4 (1.1)
Mean sleep per episode (±SEM)	1.9 (.4)	3.7 (1.4)	2.9 (.8)	2.4 (.3)
NTC				
No. of subjects	12	13	13	13
Mean No. sleep episodes (±SEM)	4.0 (.8)	5.8 (.8)	5.0 (.7)	2.9 (.3)
Mean hours sleep (±SEM)	6.4 (1.2)	9.0 (.9)	7.1 (.5)	7.9 (.9)
Mean sleep per episode (±SEM)	2.4 (.6)	1.8 (.2)	2.2 (.6)	3.0 (.4)

Correlation analysis was performed to determine the degree of association of the stress variables (sleep and psychological states) with performance at the two test sites. The significant correlations obtained are summarized in Table 4.

Psychological Trait Variables

Better performance at Fort Hood was associated with lower STAI Anxiety scores, and better performance at NTC was associated with lower EPQ Psychoticism scores. Both findings appear reasonable. However, since 34 correlations were computed between trait and performance variables, about two might be expected to achieve significance at the 5% level of confidence by chance alone.

Table 4

Significant Pearson r Correlations Between Hit Probabilities and Trait, State, and Sleep Variables

	Fort Hood	NTC
Traits		
EPQ		
Psychoticism	-.492, $p < .05$ (N=24, df = 22, $r_{crit.05}$ = .404)	
STAI		
Anxiety		-.611, $p < .05$ (N=11, df = 9, $r_{crit.05}$ = .602)
States		
STAI		
Anxiety		
baseline day		-.809, p = .003 (N=11, df = 9)
Post night battle		+.757, p = .049 (N=7, df = 5)
MAACL-R		
Sensation Seeking		
baseline day	-.511, p = .011 (N=24, df = 22)	
Sleep Variables		
Hours sleep		
0 to 24 hours pre		-.756, p = .049 (N=7, df = 5)
Sleep episodes		
0 to 24 hours pre		-.743, p = .056 (N=7, df = 5)
24 to 48 hours pre		-.938, p = .001 (N=8, df = 6)
48 to 72 hours pre		-.741, p = .035 (N=8, df = 6)
72 to 96 hours pre	-.962, p = .038 (N=4, df = 2)	

Psychological State Variables

Better performance at Fort Hood was associated with lower MAACL-R State Sensation Seeking scores obtained on the baseline day. Better performance at NTC was associated with lower STAI State Anxiety scores obtained on the baseline day and with higher STAI State Anxiety scores obtained following the night battle. However, since 136 correlations were computed between state and performance variables, at least one correlation might be expected to be significant at the 1% level of confidence and about seven to be significant at the 5% level of confidence.

Sleep Variables

Better performance at Fort Hood was associated with fewer sleep episodes during the fourth day before firing. Better performance at NTC was associated with less sleep during the last day before firing and with fewer sleep episodes during the last 3 days before firing. In this case, a total of 16 correlations were computed between sleep and performance variables for the two test sites, no more than one of which might be expected to be significant at the 5% level of confidence, and five significant correlations were obtained.

DISCUSSION AND RECOMMENDATIONS

The primary purpose of this stress evaluation was to provide data about whether the poorer performance generally obtained with TOW systems at the NTC relative to range conditions (this site difference was also obtained in this test) might be because of greater stress experienced by the TOW gunners at the NTC. The formal hypothesis of no significant difference in stress-related state measurements between the two sites was verified for all measures except MAACL-R State Anxiety. Furthermore, for this anxiety measure, the subjects were more anxious during the Fort Hood range conditions than during NTC conditions. Therefore, it must be concluded that for the conditions of this study, the subjects were not more stressed during NTC conditions and that poorer performance during those conditions cannot be attributed to a stress factor.

It should be noted, however, that comparison of the results for stress-related state measures (i.e., anxiety, depression, hostility, and stress perceptions) obtained at both sites with data obtained previously, using the same measures and procedures during stressed and control conditions in other referent protocols, revealed that subjects experienced at least moderate stress at both sites. The subjects at both sites exhibited the greatest number of significant differences in stress-related states relative to the two referent control conditions (the INDCNTRL and SSCNTRL protocols). Relative to the no-stress INDCNTRL protocol, the subjects at Fort Hood had significantly higher pre MAACL-R anxiety, pre and post hostility, pre and post dysphoria, pre subjective stress, and post specific and comparative stress ratings. Compared with the relatively low stress SSCNTRL protocol, they had significantly higher pre and post MAACL-R anxiety, pre STAI anxiety, pre dysphoria, and post specific and comparative stress ratings. Also relative to the no-stress INDCNTRL protocol, the subjects at NTC had significantly higher pre depression, pre and post hostility, pre and post dysphoria and post specific and comparative stress ratings, as well as lower positive affect. Relative to the SSCNTRL protocol, the same differences were significant except for the specific stress rating and post positive affect. The subjects at the two sites exhibited fewer and less consistent stress-related state differences relative to the referent stress protocols (ABDMSURG, WREXAM, and SSCOMP). Relative to the ABDMSURG protocol, subjects at Fort Hood had higher post hostility but had lower post depression and both MAACL-R and STAI anxiety.

They exhibited no significant state differences relative to the WREXAM protocol and differed from the SSCOMP protocol only with their lower positive affect. Relative to the ABDMSURG protocol, the subjects at NTC had higher pre depression, and pre and post hostility, and had lower pre and post MAACL-R anxiety, post STAI anxiety, and post comparative stress rating. Relative to the WREXAM protocol, they had higher pre depression and pre and post hostility. Relative to the SSCOMP protocol, they had higher pre depression, pre hostility, and pre dysphoria as well as lower pre positive affect. In summary, the comparisons with the referent protocols indicate the stress-related states of the subjects at both sites were most different from those for subjects in other protocols involving little or no stress. Their stress-related states, however, were least different from those protocols involving the stress of competition and taking an important examination, both of which represent moderate stress conditions.

The finding that the subjects were similarly stressed at both sites may be the result of an indeterminable order effect imposed by the test plan that did not provide the best experimental design to test hypotheses concerning stress differences between test sites. The test plan was established and fixed before any consideration of assessing the possible contribution of stress to anticipated performance differences between test sites. It called for testing the subjects during modified range conditions before their scheduled training and firing of TOW at the NTC. The consequence of confounding this order was to provide no experimental control for possible differential stress effects at the two test sites as suggested by the data. That is, when the subjects were tested during range conditions, the experience provided most subjects their first opportunity to fire live TOW missiles and to first test their ability to apply their training. This experience provoked higher anxiety than the subsequent firing at the NTC, as evidenced by their high pre firing MAACL-R Anxiety scores. The NTC experience, however, seems to have elicited a qualitatively different form of stress that resulted in relatively high Depression and Hostility scores, and in low Positive Affect scores. The response pattern for the subjects during range conditions was very similar to the referent group SSCOMP that involved the novel experience of rifle marksmanship in unit competition. In these two situations, the primary characteristic was relatively high anxiety that reflects the uncertainty of the situations. The response pattern for the subjects during NTC conditions, however, were much more like those for soldiers involved in fighting fires in Yellowstone National Park in 1988 (Fatkin, King, & Hudgens, 1990) who also responded with relatively high Depression and Hostility and low Positive Affect scores. In the Yellowstone report, this pattern was ascribed to as a sense of failure and frustration associated with leadership and communication of situational information (see pages 28 to 29), operational factors which are more likely relevant to the NTC than to the range firing experience.

The data available for sleep or rest patterns do not provide any indication that fatigue should be greater at either site or that this variable might contribute to a stress difference between sites.

The significant correlations obtained between sleep variables and performance at the two sites are counter-intuitive and provide no insights into the relationship between stress and performance in this investigation. Similarly, statistically significant correlations between individual trait and state measures and performance were either counter-intuitive or too few relative to the total number of correlations conducted to be considered of practical significance.

Because the present stress assessment technique involves comparison of within-study data with independent referent groups data, this study provides a reasonable assessment of the stress experienced by the subjects firing TOW missiles during range and NTC conditions. The effects of the methods and design employed could not be overcome in this study to provide an answer as to whether the lower TOW hit probabilities usually obtained at the NTC relative to range conditions might be because of greater stress usually experienced at the NTC. The usual NTC conditions combine the NTC operational factors with, in most cases, the anxiety associated with a first opportunity to fire live TOW missiles; therefore, it seems quite likely that the usual NTC conditions for TOW firing would be more stressful than either condition in this study.

If there is a future a desire to assess the effects of possible stress differences between range and NTC conditions on TOW hit probabilities at the two sites, the following recommendations are offered:

1. Choose a single number of subjects to be followed at both sites. There is no statistical advantage derived from testing a larger group at one site and a subsample of the same group at another site. Appropriate statistical procedures are applied only to the smaller number of subjects tested at both sites. Furthermore, using subsamples introduces the opportunity for bias in the selection of the subsample.

2. Select an experimental design that provides control for test order. Either of two designs can be employed:

a. Employ different groups of subjects at the two sites. It would be desirable that the groups be matched on characteristics like training and experience with firing simulated and live TOW missiles, age, physical attributes, and so forth. In this design, there is no order effect.

b. Employ the same subjects at the two sites. In this design, however, half the subjects should be tested first during range conditions and then at NTC. The other half should be tested first at NTC and then during range conditions. This design allows for statistical testing for possible order effects.

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APPENDIX A

SCORES ON PSYCHOLOGICAL STATE MEASURES AND HIT PROBABILITIES OBTRAINED FROM TWO CIVILIAN SUBJECTS AT FORT HOOD

Table A-1

Scores on Psychological State Measures and Hit Probabilities Obtained From Two Civilian Subjects at Fort Hood

	Measurement Times		
Measure	Orientation	Pre Firing	Post Firing
MAACL-R			
Anxiety	37/37	70/45	70/58
Depression	40/40	71/47	95/47
Hostility	39/39	46/46	109/46
Positive Affect	64/58	69/75	42/60
Sensation Seeking	65/55	60/69	56/69
Dysphoria	35/35	65/44	106/51
STAI Anxiety	57/49	58/51	50/43
SUBJ STRESS	9/17	17/17	64/17
SRE	10/40	40/20	50/20
Hit Probability		.00/.50	

APPENDIX B

THE WRAIR/PRECISION CONTROL DESIGN WRIST ACTIVITY MONITORING SYSTEM

THE WRAIR/PRECISION CONTROL DESIGN WRIST ACTIVITY MONITORING SYSTEM

The following description has been extracted from the following research protocol of Leu, J. R., Redmond, D. P., Belenky, G. L., Penetar, D. M., & O'Donnell, V. M. (1988). Sleep, activity and performance in military personnel during continuous simulated combat operations: 2nd Ranger battalion platoon evaluation. Washington, DC: Walter Reed Army Institute of Research, Department of Behavioral Biology, Division of Neuropsychiatry.

BACKGROUND

Activity monitoring, counting movement of the wrist, has been extensively cited in sleep/wake studies and hyperactivity. Activity monitoring is a powerful tool for the psychiatric and behavioral sciences. Movement of the non-dominant wrist has been described as an acceptable data base in sleep/wake studies, depression, hyperactivity and ergonomics. The psychiatrist can assess effects of therapy; the physician, the extent of sleep/wake disorders; the behavioral scientist, the efficacy of biofeedback; and the industrial engineer, fatigue and shift scheduling. Actigraphy is a continuous collection of wrist motion that describes one of the oscillators governing chronobiological behavior which is affected by sleep deprivation, jet travel and shift work. This data can also provide useful information in pharmacological therapeutic interventions.

The full impact of actigraphy as an important scientific and clinical instrument has been hampered by the lack of a reliable, accurate and repeatable Activity Monitor small enough for convenient data gathering. A new Activity Monitor design, based upon research and development conducted by Precision Control Design (PCD), incorporating new technology and benefitting from important discoveries made by others over many years, was introduced in January 1985. The new device is based on a low power microprocessor housed in a miniature wrist-worn enclosure. Consolidation of circuitry and improved methods of detection and signal processing has made possible a scientific tool exhibiting extraordinary capability and versatility. Being processor based, the Activity Monitor can perform many tasks normally associated with computers. The Activity Monitor and companion Terminal should interest researchers and clinicians studying human activity.

SYSTEM DESCRIPTION

The Activity Monitoring System is comprised of an Activity Monitor and a data programming and reading device. Activity data is collected by the Activity Monitor, a miniature battery driven computer with solid state memory and triaxial sensing. Programming and reading may be accomplished with virtually any personal computer by using a peripheral adapter and appropriate disc software. Alternatively, a special purpose stand alone Terminal has been developed along with all necessary software for logical step by step interaction with the Activity Monitor. Initialization data such as patient name, start/stop times and epoch interval may be programmed into the Activity Monitor by either method.

Activity data is normally collected by wearing the miniature Activity Monitor on the wrist or other body locations to suit a particular protocol. No special attention to the device is needed because of its rugged enclosure and water resistant design. Subtle arm and wrist movements are sensed by the device's electronics and stored as a function of time in resident memory. Long battery life and extended memory of the Activity Monitor permit long

intervals of data collection and storage, and a wear and forget convenience not possible before. At anytime during the data collection period, the Activity Monitor can be checked by plugging it into the Terminal or by use of an optional hand held test unit.

Data extraction is accomplished by using the Terminal in its reader mode. A 4 x 40 character display prompts the user through a series of menu items. Data may be scrolled for quick review. Alternatively, the Activity Monitor may be read by any RS-232C equipped computers by using an external box called a Peripheral Data Converter (PDC) which converts raw activity data into conventional RS-232. Custom programs for either method are available.

THE MONITOR

Wrist movement is sensed by piezoelectric bimorph bender elements. Bender output is threshold detected which accounts for the high noise immunity of the design. Data is read by a low power single chip computer which deposits number of activity counts per unit time (epoch) into 4K of resident memory. Communication with the device is accomplished through 6 external micropins on the enclosure's side. The water resistant case is 1.6" x 2.5" and weighs 3 oz.

THE TERMINAL

Initialization data is programmed into the Activity Monitor with the Terminal which also reads data. The Terminal utilizes an 8 bit processor and is designed for easy mechanical interface to the Activity Monitor. Data may be transferred from the Terminal to peripheral computers and printers using a software configurable RS-232 data link. Activity counts may be observed during on-going testing by using the Terminal in its remote mode.

DATA CHARACTERISTICS

One activity count is defined to be the amount of acceleration needed for a threshold crossing in the Activity Monitor detection circuitry. Counts are accumulated for time intervals called epochs and stored in solid state memory. When read out and plotted, the resultant graph is a time series of activity counts, an actigraph. These graphs provide revealing information about the daily movements of humans, particularly during sleep periods. During periods of high activity, counts soar to many thousands in a typical 15 minute epoch. Sleep periods are characterized by far fewer counts and often revealing information about the individual's sleep patterns, particularly those related to stages of sleep, can be obtained.

By utilizing the programming capability of the Activity Monitor, epoch times may be changed from 7.5 seconds to 16 minutes in 1/10 seconds which permit 11 hours to 650 hours (27 days) test time to fill the memory. More advanced versions of the Activity Monitor software are available that reduce the raw data according to a set of statistical algorithms. This option greatly increases the test time since only results are stored, and reduces the tedium of bulk data analysis.

APPENDIX C

DATA OBTAINED FROM A GENERAL INFORMATION AND HEALTH HISTORY QUESTIONNAIRE, A LIFE EVENTS QUESTIONNAIRE, AND PSYCHOLOGICAL TRAIT QUESTIONNAIRES

Table C-1

Means (±Standard Errors) for Selected Data Obtained in General Information and Health History Questionnaire and in Life Events Questionnaire (Form I, Recent) From 24 Military Subjects

Variable	Mean (±SEM)	
Age	21.7 (0.5) years	
Pay grade	3.7 (0.2)	(range = E2-E5)
Length of service	31.8 (4.7) months	
Education	12.1 (0.1) years	
Level of stress recently experienced	3.2 (0.3)	(1 = Unusually low 2 = Mild 3 = Moderate 4 = High 5 = Unusually high)
Overall ratings of recent positive and negative experiences		(1 = Not at all
Harmed	1.9 (0.2)	2 =
Threatened	1.6 (0.2)	3 =
Challenged	3.1 (0.3)	4 =
Successful	3.1 (0.3)	5 = Very much)
How handled recent stress	1.9 (0.3)	(1 = Very well 2 = Well 3 = Not well 4 = Adequate 5 = Poorly)
Resources	1.5 (0.2)	(1 = More than adequate 2 = Adequate 3 = Less than adequate)

Table C-2

Mean Scores (±Standard Error) on Psychological Trait Measures Obtained From 24 Military Subjects

Measure	Mean Score (±SEM)
MAACL-R	
Anxiety	50.9 (2.5)
Depression	60.4 (4.9)
Hostility	59.9 (4.0)
Positive Affect	51.3 (2.1)
Sensation Seeking	56.6 (2.1)
Dysphoria	58.4 (3.9)
STAI	
Anxiety	59.1 (0.9)
EPQ	
Psychoticism	4.8 (0.9)
Neuroticism	11.4 (1.1)
Extroversion	14.4 (1.0)
Locus of Control	
External	10.8 (0.9)
Sensation Seeking	
Thrill and Adventure Seeking	7.3 (0.5)
Experience Seeking	5.1 (0.4)
Disinhibition	5.8 (0.5)
Boredom Susceptibility	4.1 (0.4)
Total	22.3 (1.3)

APPENDIX D

MEAN SCORES (+STANDARD ERROR) ON PSYCHOLOGICAL STATE MEASURES OBTAINED FROM SEVEN MILITARY SUBJECTS FOLLOWING A NIGHT BATTLE AT NTC

Table D-1

Mean Scores (+Standard Error) on Psychological State Measures Obtained From Seven Military Subjects Following a Night Battle at NTC

Measure	Mean	(±SEM)
MAACL-R		
Anxiety	51.0	(2.3)
Depression	57.3	(7.2)
Hostility	78.1	(15.9)
Positive Affect	45.6	(4.9)
Sensation Seeking	58.4	(3.5)
Dysphoria	65.9	(9.4)
STAI Anxiety	48.0	(1.1)
SUBJ STRESS	43.9	(11.7)
SRE	38.1	(13.8)